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PROPOSED DEVELOPMENT PLAN

for Alaska DNR Parcels

GL 8 SECTION 6 1N 1E and GL1 Section 6 1N 1E

Gary W. Larsen

March 2024

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SUMMARY

The US Army is seeking to acquire via lease two AK DNR parcels to protect the Permafrost Tunnel Research Facility (PTRF) from changing drainage patterns and potential incompatible development. The two parcels, totaling 66.75 acres, are GL 8 SECTION 6 1N 1E (PAN: 660494) and GL 1 SECTION 6 1N 1E (PAN: 6900355), and are located next to the PTRF near Fox, Alaska. To protect the PTRF, the Army proposes to develop the two parcels by (1) researching and understanding the changes to the permafrost and hydrology on the two parcels, (2) adding nature based features that will restore natural drainage and redirect surface drainage away from the PTRF, (3) constructing nature based structures to restore rapidly eroding gullies and (4) emplacing temporary research equipment on the parcels to characterize the changing hydrology, monitor degrading permafrost conditions and assess the effectiveness of the nature based structures. The Army also requests AK DNR to expand the existing Mineral Closing Order (MCO) 12 to cover the entire GL 1 SECTION 6 as well as adjoining parcels TL-500 and TL-611 that would further serve to preclude incompatible development in the watershed above the PTRF.

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1.0 INTRODUCTION

Potential development and changing drainage patterns on adjoining ADNR properties threaten the safety and sustainability of the PTRF. Historical mining activity (limited to artisanal practices that ended over a century ago) combined with the changing climate have contributed to unstable drainage conditions in the watershed upslope of the PTRF. Development of the properties in the watershed above the tunnel (whether commercial, industrial, residential, or other development) would exacerbate the existing drainage and erosion problem and could result in the total loss of the PTRF, a national treasure unique in the world. Since 2011, the US Army has invested over $20 million in PTRF expansion, and upgrading and supporting facilities that are at increasing risk. Congressional support and funding are available to continue to upgrade the PTRF facilities and acquire properties above the PTRF to protect the tunnel.

1.1 Location

The US Army is seeking to acquire via lease two AK DNR parcels to protect the Permafrost Tunnel Research Facility (PTRF) from changing drainage patterns and incompatible development. The two parcels, totaling 66.75 acres, are GL 8 SECTION 6 1N 1E (PAN: 660494) and GL 1 SECTION 6 1N 1E (PAN: 6900355), and are located next to the PTRF near Fox, Alaska (Figure 1).

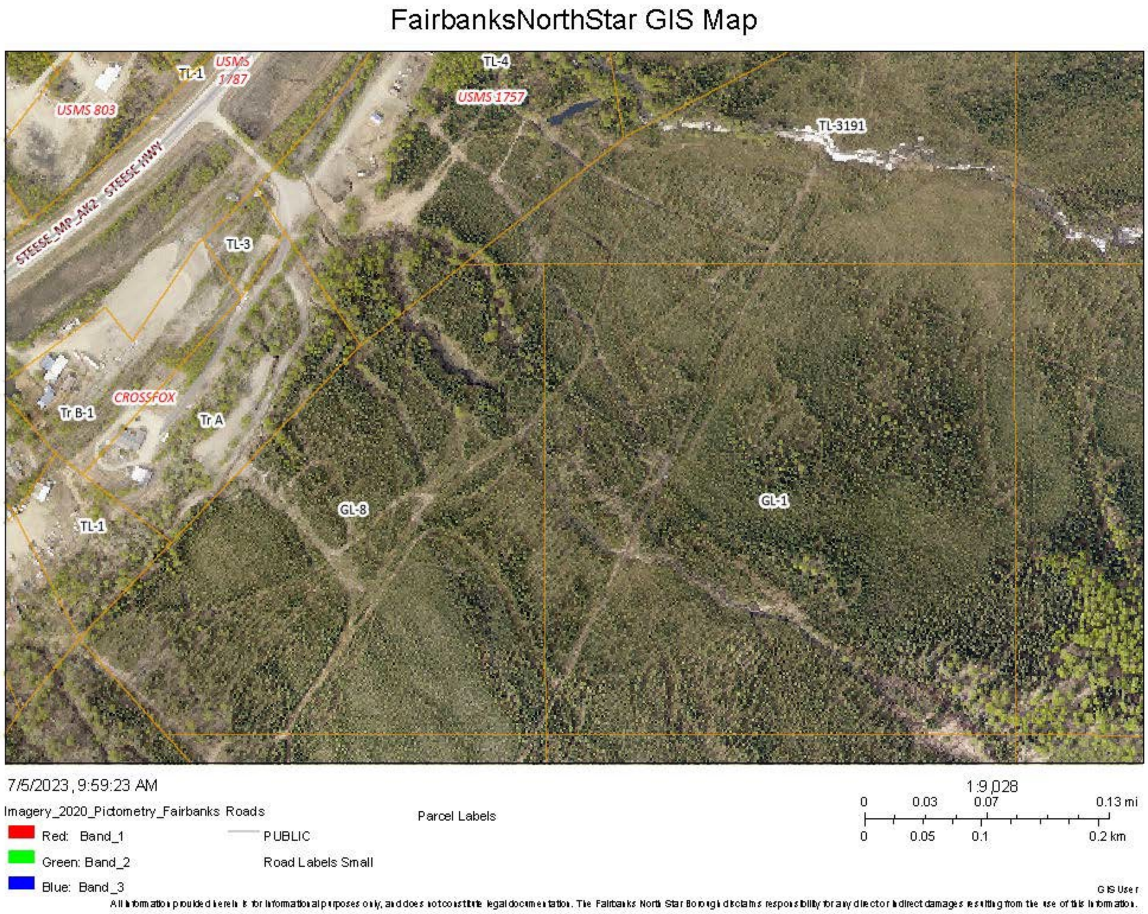

Figure 1. Alaska DNR Parcel Location.

The Permafrost Tunnel was excavated into a relatively stable escarpment between Glenn Creek and a developing gully to the southwest (referred to here as Swindle Creek). The two parcels are the primary source of surface water that feeds Swindle Creek gully. Due to changing flow patterns through the degrading permafrost on the two parcels, surface and near surface drainage has started to flow away from the Swindle Creek gully and across the surface directly towards the Permafrost Tunnel entrance (Figure2).

Figure 2. Parcel Ownership and Drainage Upslope from the PTRF.

1.2 Description of the Permafrost Tunnel Research Facility

Figure 3. Permafrost Tunnel Entrance.

Situated on a 16-acre parcel in Fox, Alaska, near the confluence of Goldstream and Glenn creeks, the US Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory (CRREL) permafrost tunnel complex is a 650-meter-long research facility dug into a large block of continuous permafrost. The Permafrost Tunnel Research Facility (PTRF) is unique, unlike any other permafrost research facility in the world. The 1963 tunnel project initiated a US and international effort to better understand permafrost that has lasted six decades. The tunnel intersects a wide range of permafrost features including ice wedges, segregated ice, thermokarst cave ice, frozen silts, gravels, and organic material. It also provides an unprecedented continuous 100-meter exposure of permafrost extending in time from the present to approximately 45,000 years in the past, with unusually complete sequences of paleo-environments (including mega-fauna bones) preserved intact. The permafrost in the tunnel represents syngenetic, ice-rich, high-organic carbon soils. The facilities at the PTRF consist of the old (north) portal and tunnel, the new (south) portal and tunnel, the visitor cabin, the safety building, three storage units, and refrigeration units. A trail heading above the tunnel provides access to undeveloped lands with modern surface vegetation and permafrost.

Figure 4. Inside the Permafrost Tunnel.

The tunnel has been used to study civil engineering and geotechnical aspects of permafrost, geology, geocryology, cryospheric science, microbial life in extreme environments, permafrost biogeochemistry, paleontology, paleoclimatology, and mining and construction techniques specific to permafrost environments (Figure 3). More than 70 technical papers have been based on research conducted at the PTRF. The site also provides a unique opportunity for research, outreach, and education; thousands of people visit the facility annually to learn about permafrost and see features firsthand. US presidents, members of Congress, cabinet members, ambassadors, state and federal agency heads, numerous researchers, and thousands of teachers, students, and administrators have studied and learned about permafrost firsthand in the tunnel.

Department of Defense and US Army Garrison (USAG) Alaska strategies for climate resilience and Arctic operations are closely aligned with CRREL permafrost and related research objectives. USAG Alaska, which owns the land where the tunnel is located, has strategic interest in the research enabled by the continued operation of the PTRF. Climate change and its impact on permafrost have implications for military infrastructure and forces in the Arctic. Lands surrounding the PTRF are experiencing altered surface hydrology and shifting vegetation regimes due to unprecedented warming. These changes present both an opportunity for critical research and a threat to the sustainability of the PTRF.

1.3 History of the Permafrost Tunnel Research Facility

The permafrost tunnel was constructed to test the potential benefits of permafrost for military applications. Located at the eastern edge of early twentieth century mining operations in the Goldstream Valley, 10 miles north of Fairbanks, the purpose of the PTRF was to explore the military applications of permafrost and, specifically, the construction of emergency shelters or storage facilities in case of a nuclear attack or Soviet invasion.

The original tunnel—including the north adit (or horizontal passage), winze (vertical or inclined passage), and gravel room—was excavated from 1963 to 1969 for the study of permafrost, geology, ice science, and mining and construction techniques specific to permafrost environments. Excavated into an escarpment left over from the area's historical gold mining, the tunnel was also used to evaluate underground excavation techniques for mining applications. It was during the excavation process that the scientific and engineering research value of the previously undisturbed permafrost and associated resources within the tunnel became clear.

To expand knowledge and understanding of scope, scale, and three-dimensional properties of permafrost, a new, south tunnel was begun approximately 200 feet to the southwest of the original, north tunnel in 2011. The south tunnel was again expanded in 2013, 2018, 2019, and 2020. The south tunnel now connects to the north tunnel with three crosscuts, creating a single tunnel complex totaling approximately 650 meters in length (Figure 5).

Expansion of the permafrost tunnel was essential to support vital research limited by the previous tunnel configuration. Expansion of the permafrost tunnel has resulted in a three-dimensional test bed for use in advancing capabilities in geophysical and remote sensing standoff detection, predictions of thaw degradation based on similar historical warm periods evident in the tunnel, and improved engineering to account for the anticipated future changes to permafrost. The additional permafrost exposed by new excavations provides access to more ice features, bones, vegetation, and soils that allows for a more holistic view of the formation history and anticipated changes to permafrost in interior Alaska. Environmental changes attributed in part to Alaska's warming climate are apparent at the PTRF, where ongoing changes to surface hydrology threaten the integrity of the permafrost to which the tunnels provide access.

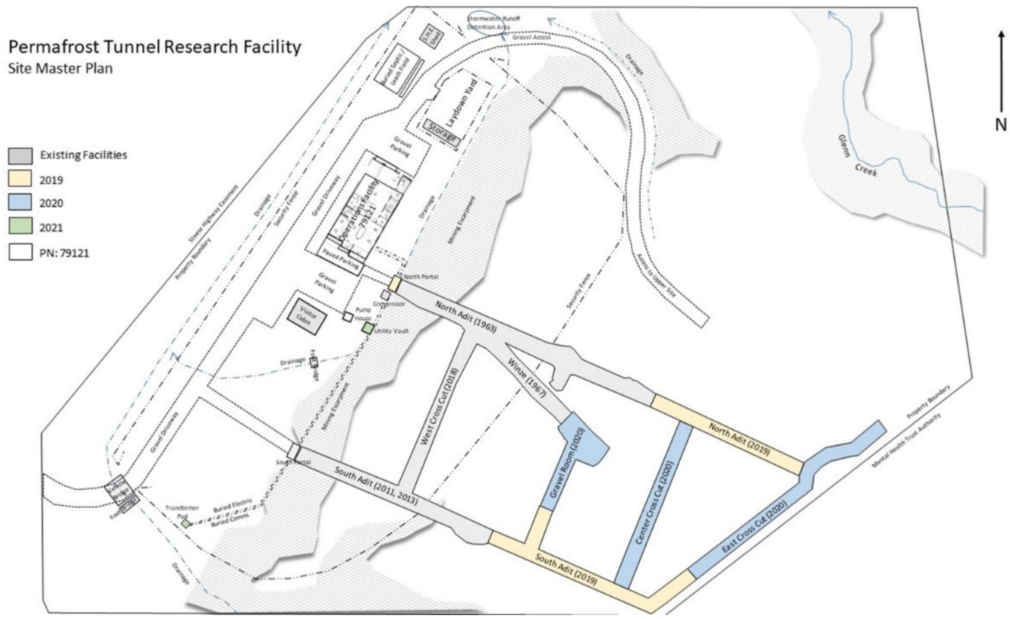

Figure 5. Permafrost Tunnel Research Facility Layout.

1.4 Challenges to Sustaining the PTRF

1.4.1 Hydrology and Climate Change

Rapidly changing drainage patterns threaten the PTRF. The hydrology on the hillside above the tunnel property is changing quickly due to climate change, historical alterations to stream channels, and ongoing recreational use. Modified drainage patterns and recreational use on the MHTA and DNR properties above and upslope of the tunnel are channeling water onto the PTRF property directly above the tunnel complex, threatening the tunnel's integrity. Historical mining activity until the early twentieth century modified the profiles of Glenn Creek and Swindle Creek, destabilizing the creek channels. The resulting headcutting and downcutting of the creeks have created unnaturally steep, unstable reaches. The local substrate of glacial silt and gravel is unable to support stable channels under these conditions, resulting in headcutting, downcutting, and lateral migration of the channels. Due to recent and future projected climate warming in the Fairbanks area, the incidence of extreme rainfall events and erosion across the hillside above the tunnel are increasing. It is critical that USAG Alaska and CRREL have permanent access and control over this land to put in place permanent drainage and erosion control structures and to allow CRREL to install protective measures if and where needed.

Figure 6. Head Cutting and Thermokarst on Swindle Creek.

1.4.2 Encroachment

Mining and subdivision expansion potentially threaten the PTRF. There are currently no limitations on the type of activities could permit on some contiguous properties (including development and mining), which could exacerbate existing drainage problems and threaten the PTRF. MHTA has notified CRREL of a potential plan to expand an existing subdivision into the watershed above the tunnel facility. Mining companies have been acquiring leases for former mining properties in the PTRF area and have announced plans to open new mines on these properties.

1.4.3 Ongoing Research in the Watershed at Risk

CRREL currently has meteorological stations and other research equipment in the watershed upslope of the tunnel on adjoining properties. This research equipment and the long-term experiments that depend on the equipment are at risk because the permit has not been renewed. A major aspect of permafrost research and engineering is the vegetation/ecotype above the permafrost. Currently, CRREL has permanent access only to the spruce forest ecotype immediately above and surrounding the tunnel, but the properties east of the tunnel provide access to mixed birch and tussock tundra ecotypes. Permanent meteorological stations and other equipment need to be installed on the adjoining property.

2.0 PURPOSE

The purpose of the proposed lease is to protect the safety and sustainability of the PTRF by: (1) precluding incompatible development on the adjoining properties that threaten the tunnel, (2) enabling the implementation of erosion control measures on properties where changing drainage patterns threaten the facility, and (3) deployment of research equipment on the adjoining property.

3.0 PROPOSED DEVELOPMENT

The Army proposes the following development on the two DNR parcels:

- Research and understand the changes to the permafrost and hydrology on the two parcels.
- Add nature based features that will restore natural drainage and redirect surface drainage away from the PTRF.
- Construct nature based structures to restore rapidly eroding gullies.
- Emplace temporary research equipment on the parcels to characterize the changing hydrology, monitor degrading permafrost conditions and assess the effectiveness of the nature based structures.
- Expand existing MCO to cover all of parcel GL-1 and add a new MCO on adjoining parcels TL-500 and TL-600.

3.1 Research and Understand Changes to Hydrology and Permafrost

The Army proposes to learn and understand the changing hydrology on DNR parcels. Current observations indicate that subsidence from permafrost thaw leads to surface ponding and surface ponding warms substrate underneath. Earlier active layer thawing and increased rainfall are exacerbating sub-surface erosion leading to new flow paths. In addition, sub-surface flow at the bottom of the active layer increases potential for thermokarst and new flow paths into groundwater (Figure 7). As the Army learns new information about the hydrology in the watershed, the Army may propose research, development or encroachment protection on additional DNR parcels.

Figure 7. New Drainage channels developing above the PTRF.

3.1.1 Review Existing Data

There are several existing data and studies that may be useful in providing further understanding of the site's system and to inform potential solutions. These data sources may not represent the in-stream conditions or localized conditions but provide information on the surrounding environment and may be used as a reference location representative of the stream systems uphill from Swindle and Glenn creeks. These data sources include:

- Borehole (10m deep) data set in trail vicinity
- CIPRI cores (1-3m) for microbes, carbon
- Ground penetrating radar in trail vicinity
- Electrical resistivity in trail vicinity
- Borehole (1-3m deep) nuclear resistivity data
- Lidar (2017)
- Hyper spectral imagery (2014 and 2017)
- Ecological investigation
- Thermistors for temperature (5-6 years)
- Pressure transducers in Glenn Creek
- Airborne Synthetic Aperture Radar (AIRSAR) imagery

3.1.2 Identify Data Gaps

There are several data gaps which need to be filled in to gain a better understanding of the site's system and to inform potential solutions. These gaps included, but are not limited to:

- Vegetation elevation
- Topography - Light Detection and Ranging (Lidar)
- Surface flow (flow direction, flow velocity, flow volume, with respect to seasonality)
- Sub-surface flow (flow direction, flow velocity, flow volume, with respect to seasonality)
- Hydrological and hydraulic modeling
- Geophysical data

3.1.3 Identify Drainage Patterns

The Army proposes to map historic and current drainage patterns.

3.1.4 Monitor Surface and Near Surface Changes

The Army proposes to expand the study done in 2016 using remote sensing and LIDAR to map subsidence over time (Figure 8).

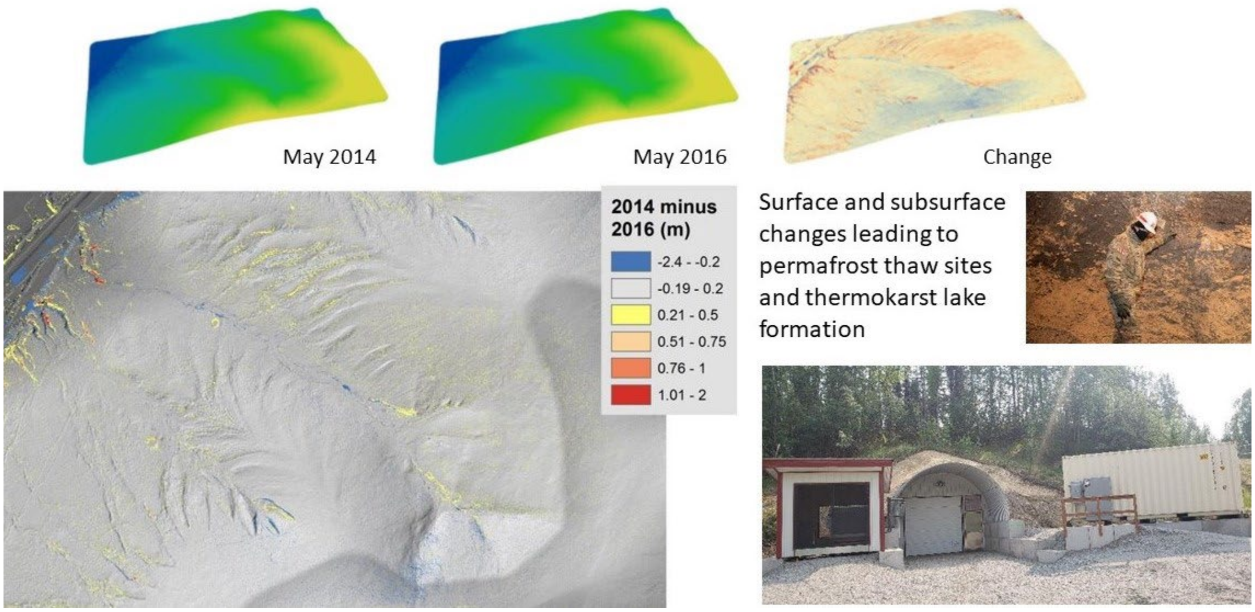

Figure 8. Monitoring Surface and Near Surface Changes in the Watershed.

The Army proposes to install additional transects to understand changing permafrost patterns at depth such as those shown in Figure 9. The top image shows true color image of a 500 meter transect above the Permafrost Tunnel with features identified. Thermokarst features have been expanding rapidly since 2016. The middle image shows end of season thaw depths (active layer) have increased up to 100% since 2013. It is apparent that the large thermokarst features are growing laterally and vertically. The bottom image was created using electrical resistivity tomography which shows frozen zones (green and blue) and areas of thaw (orange and yellow). Ice wedges and thawed regions can be imaged in the subsurface. These are confirmed with boreholes.

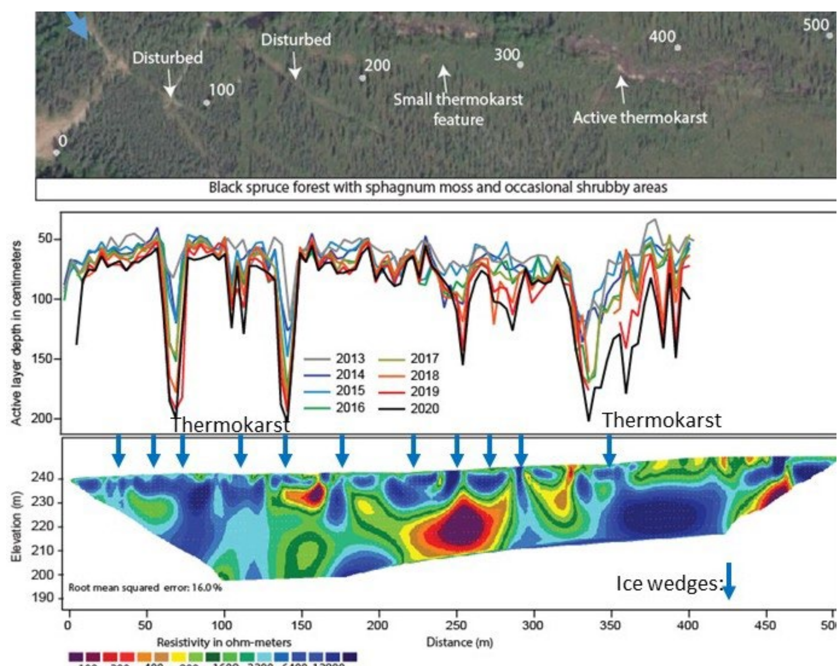

Figure 9. Surface Transect Above the PTRF.

3.2 Employ Nature Based Solutions to Restore Natural Drainage.

3.2.1 Design nature based solutions to redirect drainage.

The challenge in designing any solution to redirect drainage on a highly sensitive and fragile hillside underlain by very warm permafrost is that any diversion solution may make the problem worse, not better. Surface water flows beneath the vegetative layers, often at the boundary between frozen and unfrozen material. As the active layer deepens throughout the summer, near surface run off can flow further beneath the surface, ultimately down to the top of the permafrost layer. Predicting the path of the near surface flow is difficult because the thick vegetative layer often makes changes in the topography that directs flow. Further complicating the issue is when waterflows down into the permafrost in a process called thermokarst. Flow direction in thermokarst is even more unpredictable that near surface flow and can cause thermal erosion of the permafrost, destabilizing the area even more.

On January 8, 2024, the Army held a workshop to discuss “Engineering with Nature” nature based options for restoration. The team developed a number of principles that would be useful is successfully developing nature based solutions to divert drainage while not degrading the underlying permafrost.

- Employ nature-based solutions versus hard-engineered solutions.
- Maintain or increase shading of the site using material options that would act as an insulator to the permafrost layer.
- Use natural materials from near but not directly on the project site.
- Avoid any solution that encourages the ponding of water.
- Use local native species for revegetation.

Nature based solution are much more palatable than installation of hard features at the site. Because of the sensitivity of the site, there are limitations on the use of heavy construction equipment. It may be possible to use larger equipment when ground is frozen (non-spring periods).

The project team discussed material options that would not degrade and increase the temperature of the permafrost layer. Possible use of coir fiber logs, saw dust, chipped tree branches were recommended. The team also suggested following-up on ongoing studies into insula☐ng materials for use in permafrost environments.

The project team discussed the incorporation of existing on-site materials into design considerations. Considerations must be given to cutting branches from trees and possibly removing shading of the permafrost.

- Design would ensure the use of branches of already fallen trees.
- Currently the tree canopy consists of layers of varying tree heights and if branches are needed to be cut from trees that are not fallen, they would be taken

from the trees at a lower height within the canopy, to reduce removing shade protection of permafrost.

The project team also discussed challenges with designs that promote ponding of water. The goal is to develop alternative solutions that would reduce water velocity enough to mitigate erosion, downcutting and headcutting, but avoid ponding. Ponding water can potentially increase temperature of permafrost layer due to trapped energy and would need to be considered. Some ideas were to possibly design smaller shaded ponds and check dams filled with sediment may be a possible solution.

The project team discussed the possible types of vegetation species used in designing a solution. a. Consideration should be given to using native and/or existing vegetation species within the site and/or in the surrounding environments or streams.

- Possibly using brush matting made from native willow species such as Pacific willow (*Salix lasiandra*), undergreen willow (*Salix commutata*), litle-tree willow (*Salix arbusculoides*) or other woody native plant species such as Dwarf birch (*Betula nana*), and Labrador tea (*Ledum palustre),* as appropriate for permafrost areas.
- New vegetation would require cuttings not plantings within these permafrost site conditions.
- A search of the environment surrounding the site to assess which vegetation species are thriving in this permafrost environment would be beneficial.
- Transportation option for new vegetation would be to sling the vegetation in from a nearby site being salvaged/cleared.

3.2.2 Install Nature Based Diversion Structures.

Based on design considerations discussed above, the Army proposes to install up to five nature based diversion structures to redirect Swindle Creek from following its new path (red dotted line in Figure 10) back into the large gullies where Swindle Creek has traditionally flowed.

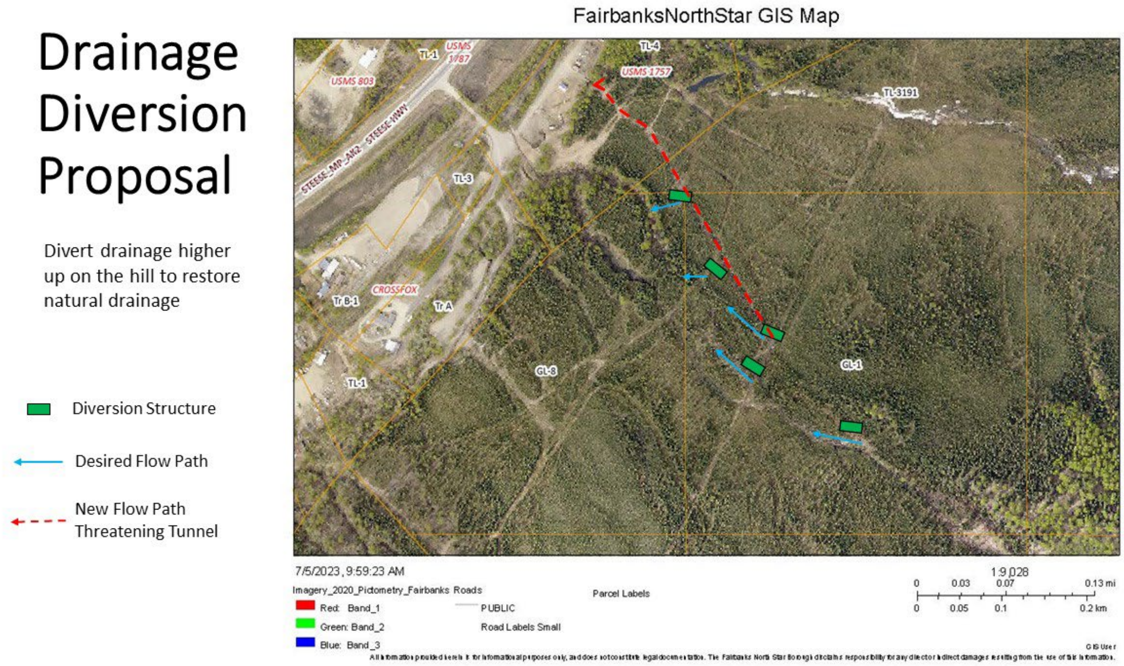

Figure 10. Drainage Diversion Proposal.

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3.3 Employ nature based solutions to restore rapidly eroding gullies.

3.3.1 Design Nature Based Solutions to Restore Gullies.

The Engineering with Nature workshop also discussed methods to increase stream stability and reduce stream erosion in Glenn and Swindle creeks. Techniques included increasing roughness within channel, securing structures to available media, stabilizing banks strategically to prevent widening and still supply sediment, and using adaptive management to build sediment layers. Restrictions that were considered in the development of potential solutions included limited/no access for large machinery, no disturbance of permafrost layer, and regulatory concerns.

Glenn and Swindle creeks are not classified as one stream type but have the characteristics of a combination of stream classifications (A, F, and G). Due to the permafrost acting as a confining layer, the stream channel is widening instead of narrowing and deepening, leading to an unstable stream channel.

The streams have steep slopes, high water velocities, and very fine sediment (silt).

As discussed above, traditional stream stabilization and NBS stream restoration techniques differ. Traditional Stream Stabilization uses hard infrastructure components (e.g., stone armoring, significant grading) to shape a degraded stream into a static stream system. NBS Stream Restoration Techniques uses natural materials (onsite vegetation, brush matting) applied with minimal disturbance to allow the stream to revert to its natural state. Stream restoration NBS components which could be used within Glenn and Swindle creeks include root wads from fallen trees, tree limbs/trunks from fallen/cut trees, and brush mat.

Three concepts were presented to address stream erosion and instability.

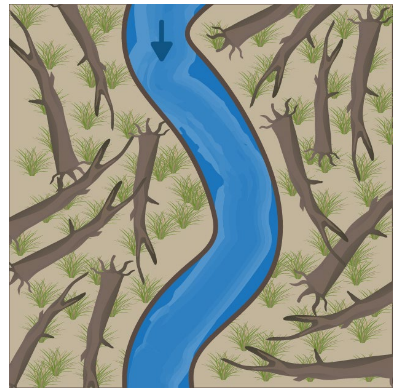

Figure 12. Concept 1.

Concept 1 (Figure 11): Uses branches from fallen trees positioned to lay flat in their current location and install brush matting on exposed banks. Starts from downstream and moves upstream over time. This method would be the lowest cost and level of effort, but also the longest time to reach end stabilization goal.

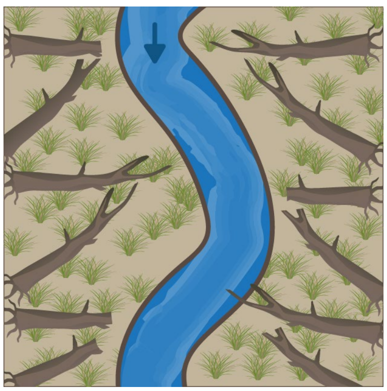

Figure 11. Concept 2.

b. Concept 2 (Figure 12): Uses varying lengths of branches from fallen trees positioned to lay flat and promote channel sinuosity, perform grade control along tree branches perpendicular to flow, and install brush matting on exposed banks. This method also starts from downstream and moves upstream over time. This method would be a moderate cost and level of effort.

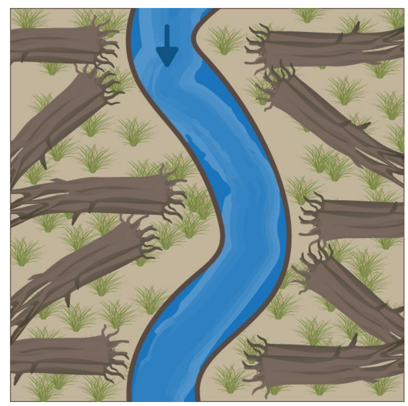

Figure 13. Concept 3.

c. Concept 3 (Figure 13): Uses varying lengths of branches from fallen trees installed into bank with a jet cuter to promote channel sinuosity, perform grade control along tree branches perpendicular to flow and install brush matting on exposed banks. This method would be the highest cost and level of effort.

3.3.2 Install Nature Based Solutions to Restore Gullies.

The Army proposes to restore gullies using nature based solutions such as root wads from fallen trees, tree limbs from fallen/cut trees and brush mats including willow staking (Figure 14).

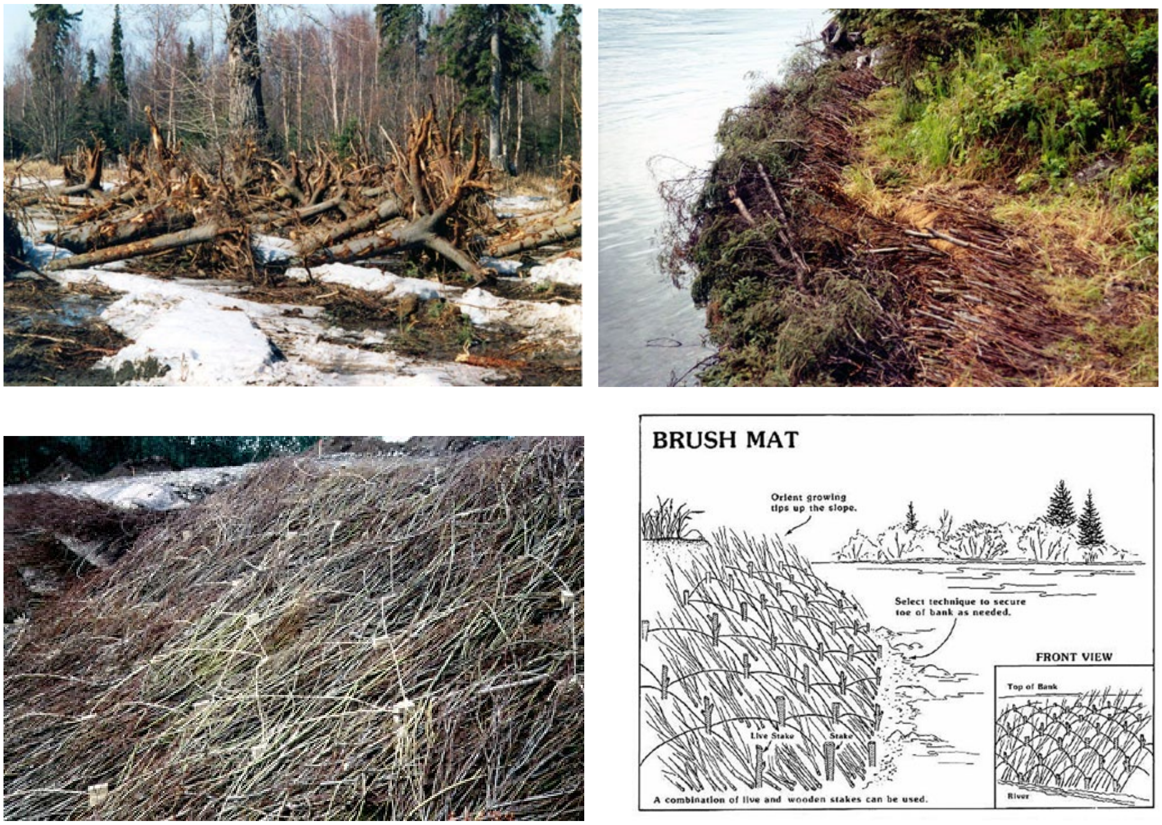

Figure 14. Nature Based Stream Restoration Techniques.

Techniques to accomplish gully and stream restoration include increasing roughness within channel, securing structures to available media, stabilizing banks strategically to prevent widening and still supply sediment, and using adaptive management to build sediment layers (Figures 15 through 20).

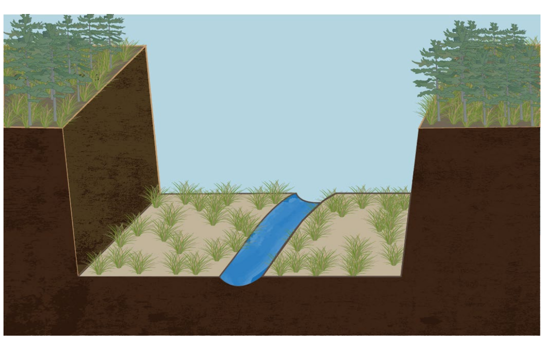

Figure 15. Existing Condition.

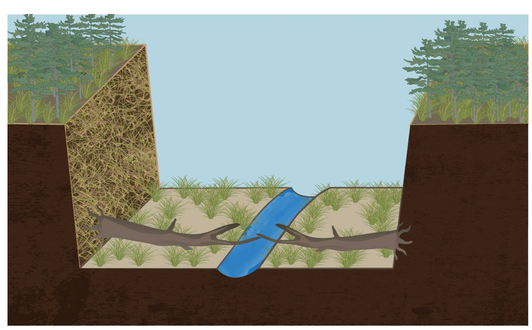

Figure 16. Placement of Structures.

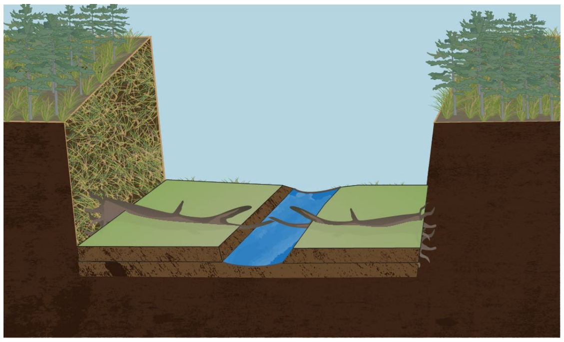

Figure 17. Aggradation of Sediment.

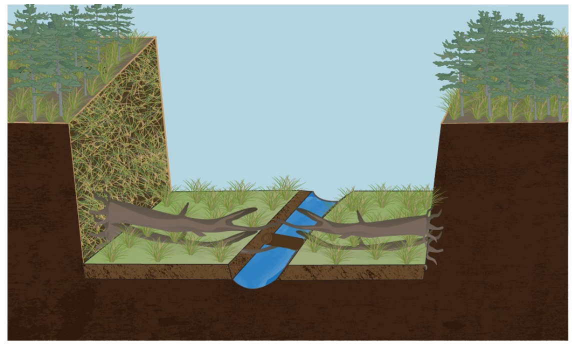

Figure 18. Stabilization of Sediment and Placement of Structures.

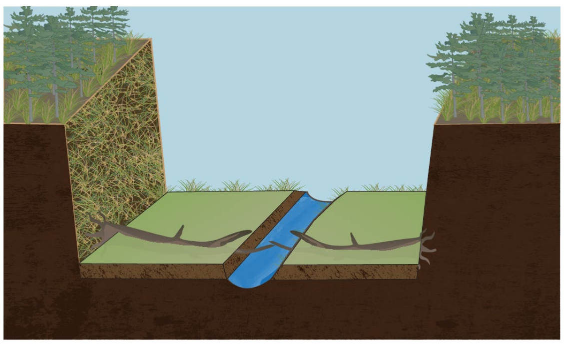

Figure 19. Aggradation of Sediment.

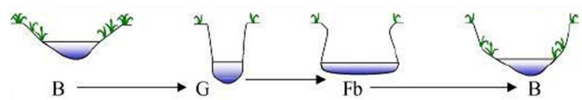

Figure20. Stream Classification Evolution.

3.4 Conduct long term research to understand impacts of changing climate on permafrost and monitor effectiveness of nature based structures.

The Army proposes to place long-term temporary research equipment on the proposed leased lands to gain an understanding of the changes happening to the drainage, to the permafrost and to the success of nature based erosion structures. Examples of the types of research equipment to be deployed are shown below in Figures 21-23.

Figure 21. Meteorological Instrumentation.

Figure 22. Hydrological Instrumentation. Figure 23. Ground Temperature Instrumentation.

3.5 Preclude Incompatible Development

The Army is seeking ways to preclude incompatible development on the two parcels GL 8 SECTION 6 1N 1E (PAN: 660494) and GL 1 SECTION 6 1N 1E (PAN: 6900355). One method to preclude incompatible development is to expand the existing Mineral Closing

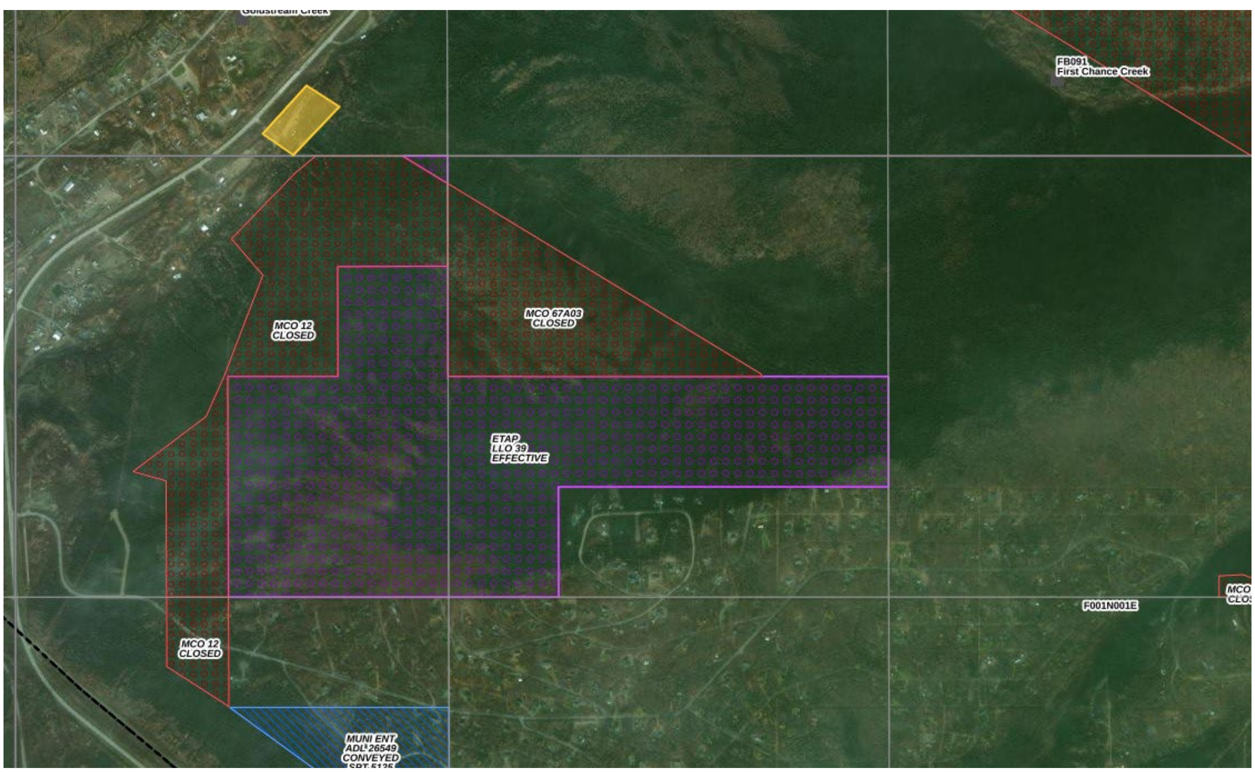

Figure 24. Existing MCOs and LLO near the PTRF.

Orders (MC)). There is an existing MCO – MCO 12 – that covers most of the two parcels the Army is seeking to lease (Figure 24). The Army requests AKDNR to maintain existing MCOs (MCO 12 and MCO 67A03) and proposes that AKDNR close the northwest portion of GL 1 SECTION 6 1N 1E (PAN: 6900355) so that both parcels are completely under an MCO. The Army also requests AKDNR to close two additional parcels totaling approximately 400 acres higher up in the watershed, TL -500 1N 1E Block 5, Lot 500, PAN (165956), and TL-611 1N 1E Block 6, Lot 611, PAN (660502), currently covered by ETAP LLO 39 (Figure 25). Closing these parcels would protect the sensitive watershed extending between the existing subdivision all the way down to the PTRF.

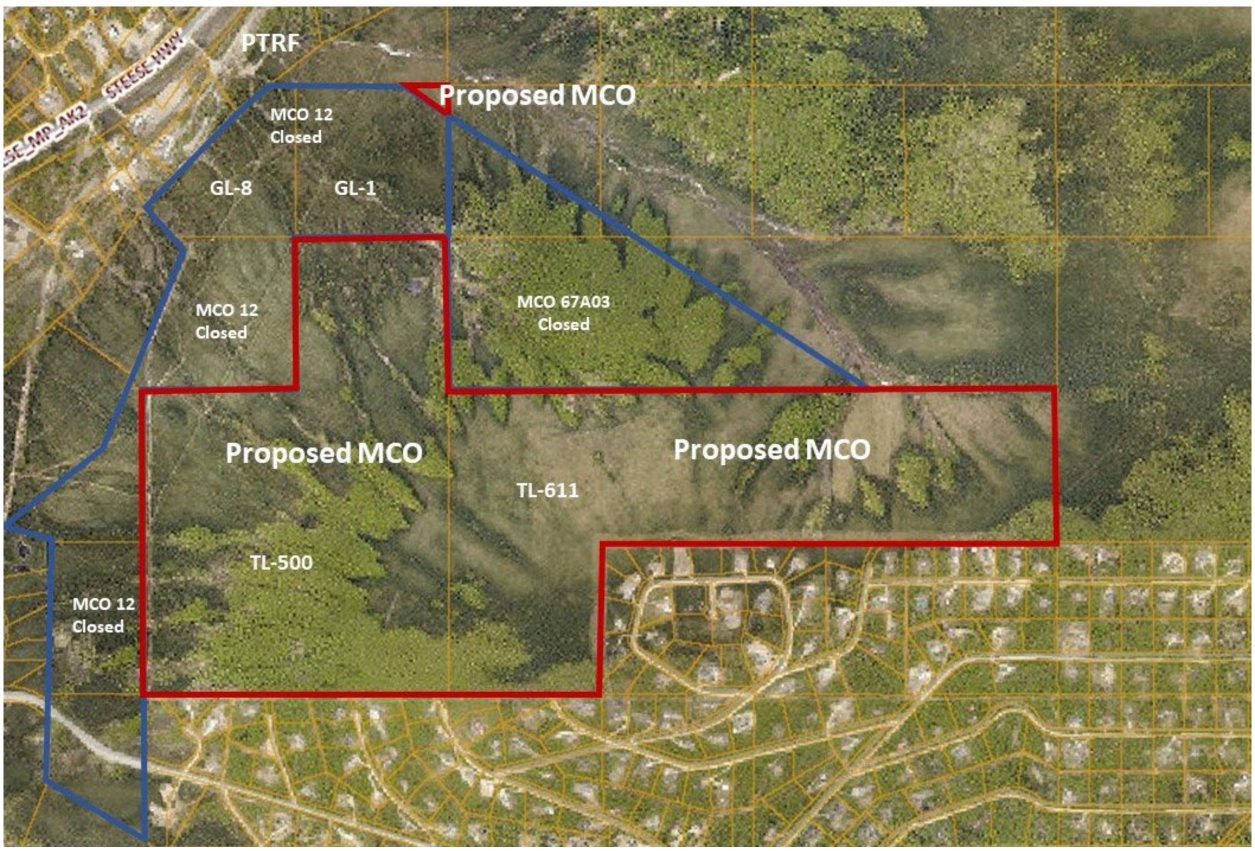

Figure 25. Proposed MCOs.

4.0 CONCLUSION

The US Army is seeking to acquire via lease two AK DNR parcels to protect the Permafrost Tunnel Research Facility (PTRF) from changing drainage patterns and potential incompatible development. The two parcels, totaling 66.75 acres, are GL 8 SECTION 6 1N 1E (PAN: 660494) and GL 1 SECTION 6 1N 1E (PAN: 6900355), and are located next to the PTRF near Fox, Alaska. To protect the PTRF, the Army proposes to develop the two parcels by (1) researching and understanding the changes to the permafrost and hydrology on the two parcels, (2) adding nature based features that will restore natural drainage and redirect surface drainage away from the PTRF, (3) constructing nature based structures to restore rapidly eroding gullies and (4) emplacing temporary research equipment on the parcels to characterize the changing hydrology, monitor degrading permafrost conditions and assess the effectiveness of the nature based structures. The Army also requests AK DNR to expand the existing Mineral Closing Order (MCO) 12 to cover the entire GL 1 SECTION 6 as well as adjoining parcels TL-500 and TL-611 that would further serve to preclude incompatible development in the watershed above the PTRF. As new information is gained about the hydrology in the watershed, the Army may propose research, development or encroachment protection on additional DNR parcels.

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